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The Problem of Studying Minimum Flow (Runoff)

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THE PROBLEM OF STUDYING MINIMUM FLOW (RUNOFF)*

The existing research methodology of winter and summer minimum flow in regions having severe climatic conditions, e.g. where the rivers freeze in winter and dry up during summer, suffers from a number of significant drawbacks. Above all, no account is taken of the phenomenon of surface water transition into alluvium and vice versa, or its accumulation in the form of ice coatings along the river bed, river valley, and the entire basin.

There is a total exclusion of such important factors as the observation of the levels and chemistry of separated water stretches which were formed as a result of freezing or drying up, or the estimate of the volume of ice coating in the river basins beyond Lake Baikal, where the snow layer is negligible, and any April or May flow for a number of rivers is due to the thawing of their ice coatings.

The solution to the problem of utilizing rivers for numerous branches of the national economy, at the current level of technical demands, is possible only through the results of an analysis of river flow coupled with research on the dynamics of the subsoil waters of valleys, expressed in the form of alluvial and subriver bed streams.

In those instances when a river, in view of climatic and other conditions, does not use up water, river flow does not always cease, but assumes other concealed aspects, so to speak. During the flowless period, the subsoil water supply of the river basin, which adjoins the river valley, enters the alluvial and subriver bed stream, which is quite intimately bound up with surface waters, and in a number of cases cannot be separated from them.

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Here we do not touch upon cavern forming phenomena, when the river as a whole can turn into a subsoil stream, which in principle differs from the alluvial valley waters. In actual practice, in the study of minimum river flow for purposes of planning and construction, it is frequently impossible to separate the hydrological and hydrogeological domains.

Transition of surface water into alluvium, and vice versa, is common to rivers of different basins, but is expressed more vividly in regions of continental climate; for rivers located in mountainous regions, and plains, the nature of this interaction has its own distinguishing features.

To cite one of the simpler of the numerous examples, we can refer to the mountainous region of the Sarala River (basin of the Black Iyus and Chulym rivers), where, over an area 8-10 kilometers long, discharges from 0.2 to 2.3 cubic meters per second were measured during summer, and in the winter, during the general periodic cessation of flow, there are areas having a discharge of 0.2 to 0.4 cubic meters per second.

Exceptionally peculiar characteristics of the winter flow obtain for all the rivers of the bleak Trans-Baykal region, and also for rivers in other regions of Siberia and the Urals.

According to the data of GGI* manual, the Shilka River, at the city of Sretensk, (F = 172,000 square kilometers) freezes during some years (6 times during a 40 year period). Such a situation leads to great difficulties in planning the utilization of the river for water supply purposes over the entire upper portion of the basin. The degree of departure of such a conclusion from reality is shown by the results of special research on the Shilka River at Kholbon (F = 165,000 square

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kilometers), which is located 105 kilometers above Sretensk.

In the years 1946 and 1945, the minimum river discharge at Sretensk was determined to be 0.36 and 0.1 cubic meters per second, while in the direction of Kholbon, the corresponding discharge was 2.1 and 0.8 cubic meters per second, i.e. 6-8 times as great.

In the year 1933, the Shilka River froze at Sretensk from February 1st until April 1st, while in the direction of Kholbon, flow was observed during the entire winter.

Finally, according to the data of an annual publication in the year 1941, minimum discharge at Sretensk amounted to 1.59 cubic meters per second as compared with 2.22 cubic meters per second in the direction of Ust'-Onon, which is located 150 kilometers higher.

It can be considered an established fact that the magnitude of winter discharges over any given area of the Shilka River, the upper part of the Zeyal River (Bomiak region) and other large rivers of the Trans-Baykal region, cannot be judged by measurement data in one direction. Freezing of the separate sand banks of such a river is very frequently an indicator of the transition of surface water into the subriver bed stream. This is confirmed by the presence of river current literally one hundred meters below or above the frozen area. A very convincing confirmation of the presence of the mentioned subriver bed stream at the Shilka River (as well as at the Zeya River) is the absence of river bed ice coatings. The magnitude of the sub-river bed stream as compared with the winter minimum can be appreciable for the rivers of the Trans-Baykal region, and it depends on the geological structure of the valley, lithology and thickness of alluvial deposits. Thus, over the area between Kholbon and Sretensk, the width of the valley of the Shilka River is between 0.8-5.5 kilometers, depending upon its geological structure. In the line of direction of Kholbon, the studies of years 1945 and 1946 of the critical winter period, for the valley width of 1.6 kilometers and thickness of water deposited alluvium of 5-8 meters, represented by the gravel-pebble and coarse sand material, the discharge of the sub-river bed stream was determined as 0.12-0.15 cubic meters per second.

The magnitude of a subriver bed stream in any given direction can vary slightly during the year, almost independently of the river water expenditure. However, since the subriver bed stream depends on the geology of a given area, its magnitude, over a comparatively short stretch of river, can change very greatly in view of corresponding decrease or increase of the river's water discharge.

In the light of this information, we can understand the freezing over of the Shilka River at Sretensk, and of separate areas of analogous rivers of the Trans-Baykal region and the northwestern part of the DVK [Far Eastern Kray].

No less peculiar is the winter behavior of average and small rivers of the Trans-Baykal region.

Rivers with basins of 2000-10,000 square kilometers and higher (Nyercha, Uryum, Ogodzha, Tok rivers, and others, basins of the Shilka, Zeya, Bureya rivers) freeze over every year, if not over their entire length, then over the greatest portion of the sand banks. Together with this, the cessation of surface flow there can be regarded only as conditional, since the remaining numerous stretches of water are almost always interconnected through the alluvium. At separate sand banks of rivers of this type, in view of considerable freezing over of alluvium, there are formed ice coatings; usually, however, part of the water flows through the subriver bed stream. This is the principle underlying the utilization of water stretches for the water supply of industrial enterprises and rail transport. Examples of this are furnished by the Uryum, Ogodzha, and certain other rivers.

Finally, small rivers of this zone with watersheds from several tens to one thousand square kilometers, which freeze all the way to the bottom, are not, with the exception of separate deep stretches, completely inactive during winter.

The basic process of winter flow there, takes the form of river bed ice coatings; along with this, numerous river areas of the contemplated region have comparatively thick alluvial deposits which, to a considerable degree, are irrigated by water. The alluvial stream, in a number of cases, possesses a relatively high water capacity, receiving its supply from deep, predominantly interstitial waters.

In the Trans-Baykal region (basins of rivers Nerch, Uryum and Shilka) there are several so-called watershed galleries constructed which drain off the alluvial and subriver bed waters. In one instance, for a watershed less than 30 square kilometers during the critical winter period, the gallery yields reached 17 liters per second, while in another case, for a watershed of 11 square kilometers, the gallery yield was 10 liters per second. The value of such a quantity of water is evident from the fact that the inflow of 10 liters per second is adequate to supply a population of 6000 persons, and to assure the operation of a 1500-kilowatt diesel power house.

The above-cited examples of galleries are far from being unique, and on the basis of experience with the existing systems, a number of new water enclosures are being planned and constructed. Of a somewhat different character is the minimum flow of the rivers of Northern Kazakhstan: basins of Nura River, partly of Ishim River and some other closed basins of Lake Seleta-Teniz, Lake Altay-Sor and others.

In addition to winter freezing, rivers of this zone dry up during summer; for rivers of average basins, flow ceases only at isolated sand banks, and at small rivers there remain only small watery stretches.

However, in practice, there is no cessation of flow here in summer, with the supply mechanism of the river network taking two basic forms. In some cases, a continuous stream is traced along the river, which filters through the alluvium at the dried up sand banks.

The example of this type of flow is furnished by the Seleta-Teniz River (basin of Lake Seleta-Teniz) in the zone of the village of Gl'inskiy (F = 9500 square kilometers); in August 1939, on a 20 kilometer parcel, there was observed here, while some sand banks were being dried up, a discharge at others of from 0.1 to 0.3 cubic meters per second. An analogous cycle is observed at the adjacent rivers Uleta and Chiderta.

Over another considerable portion of basin of the contemplated region, in view of silting of alluvium, the river is subdivided into sections of different lengths, which include one or several water stretches; the cycle of these water sources is determined by the degree of feeding received from the subsoil waters. Such a cycle is inherent primarily in rivers of Northern Kazakhstan.

The feeding of river areas of the second subdivided type has two varieties.

In many water stretches, during the summer "flowless" period, a considerable lowering of water level takes place in view of insufficient subsoil feeding, and there occurs an increase in mineral content in the water. At the same time, other water stretches, during the course of a hot summer and metric evaporation, preserve their level due to abundant feeding by the subsoil waters of the original rock formations or the subriver bed stream, which flows from the upper part of the river. Sometimes both of these feeding factors are active, depending on the season and meteorological conditions, which prevail one over the other.

Economic utilization of these water stretches in some cases is highly effective. Thus, the water stretches of the Kyz-Dzhar River (F = 350 square kilometers, basin of Seleta-Teniz River) and the Bogumbay River (F = 400 square kilometers, basin of Lake Altay-Sor) practically did not experience summer lowering of level, when the water was used for irrigation purposes in quantities considerably in excess of volumes of water stretches (in excess of 100 and 300,000 cubic kilometers).

In the first instance, the water stretch is supplied by the waterbearing layer of carboniferous limestone, and in the second instance by the interstitial waters of solid granite.

The hydrogeological conditions of separate water stretches of the same river can vary widely, depending on the geology of the parcels. Thus, study of the balance of two isolated water stretches, downstream of Bogumbay River, in the years 1939-1941, which were spaced 4 kilometers apart in different sections as to water capacity of the geological formations, showed a larger inflow for the water stretch where the conditions of subsoil feeding were more favorable.

Cited examples of utilization of water stretches are by far not isolated, and it can be affirmed that the existence of water stretches is due to the presence of constant subsoil water feeding.

The above-mentioned factual data on the formation and cycle of minimum river flow in isolated and climatically severe regions applies to some degree to other oblasts of the USSR, primarily to its Asiatic part.

In conclusion we can state that the existing system for the observation of river cycles does not satisfy all of the growing demands of a number of branches of the National economy. Hydrometric data of UGMS* for the Asiatic part of the Union shed inadequate light upon the problem of minimum river flow, and in a number of cases led to erroneous conclusions; necessity of improving the operating system of the stationary hydrological network is obvious.

It is probable that such research, embracing large territories, will require cooperation with the Ministry of Geology, and in addition the consulting services of hydrologists.

At any rate, the study of surface flow, especially at special flow stations, should foresee the study of problems connected with alluvial waters of the valley, and, above all, questions connected with the subriver bed flow.

At hydrological stations of general type, during the periods of minimum flow and especially during the "flowless" period, all measurements of water discharges should be made, not into a rigidly established direction, but over the distribution area of several sand banks and water stretches (morphometric river complex). The length of the studied area is determined with relation to the capacity and cycle of the river.

On rivers that dry up, special attention should be devoted to

* [Local Administration of Hydrometeorological Service]

the study of level cycle and chemistry of the water stretches; only in such a way can we get a valid idea of minimum flow in the general pattern of river cycle.

The practice of complex studies of river flow has firmly entered the system of planning-research organizations and is primarily stimulated by the water supply requirements of the developing industrial, and, especially, mining, construction, and transport enterprises.

As a high priority project, it would be expedient to begin the collection and generalization by UGMS of rather voluminous, but unused data contained in the works of GGI, dealing with the study of surface alluvial waters, which is available in research and planning institutions and organizations (Ministry of Geology, Ministry of Non-ferrous Metallurgy, Ministry of Transport, etc.)

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